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(54) MIMO SIGNAL GENERATOR WITH FREQUENCY MULTIPLEXING

MIMO-SIGNAL-GENERATOR MIT FREQUENZMULTIPLEXIERUNG

GÉNÉRATEUR DE SIGNAL MIMO À MULTIPLEXAGE EN FRÉQUENCE

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Description

TECHNICAL FIELD

[0001] The invention relates to a signal generator for generating MIMO signals, a measuring system comprising such a signal generator and a measuring method.

BACKGROUND ART

[0002] During recent years, more and more MIMO devices are being used. A MIMO signal consists of a number of individual partial MIMO signals in the same frequency range with the same carrier frequency, emitted by different antennas in order to achieve spatial diversity.

[0003] In order to generate a MIMO signal, conventionally a completely separate signal generator is used for each MIMO signal. Especially in a measuring setup, this requires a great deal of individual measurement devices. For example, US 2017/0187477 A1 shows such a MIMO device.

[0004] Accordingly, one object of the invention among others is to provide a MIMO signal generator, measuring system and measuring method, which allow for generating a MIMO signal with a minimum number of components.

SUMMARY OF THE INVENTION

[0005] This object is achieved by means of the features of the independent claims.

[0006] The dependent claims develop further the central idea of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] An exemplary embodiment of the invention is now further explained by way of example only with respect to the drawings, in which

Fig. 1 shows a measuring system and a MIMO signal generator not according to the invention but for illustration purposes only;

Fig. 2 shows a MIMO signal generator according to the invention;

Fig. 3 shows an exemplary partial MIMO signal;

Fig. 4 shows an exemplary signal generator output signal of the MIMO signal generator;

Fig. 5 shows a frequency shifted partial MIMO signal in an exemplary MIMO signal generator;

Fig. 6 shows a frequency shifted partial MIMO signal in an exemplary MIMO signal generator;

Fig. 7 shows a frequency shifted partial MIMO signal in an exemplary MIMO signal;

Fig. 8 shows a frequency shifted partial MIMO signal in an exemplary MIMO signal;

Fig. 9 shows a frequency shifted partial MIMO signal in an exemplary MIMO signal generator;

Fig. 10 shows a frequency shifted partial MIMO signal in an exemplary MIMO signal generator;

Fig. 11 shows a resulting partial MIMO signal in an exemplary MIMO signal generator;

Fig. 12 shows an embodiment of a measuring method.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0008] First we demonstrate the construction and function of a measuring system, apparatus and signal generator in Fig. 1.

[0009] Along Fig. 2, an embodiment of the signal generator according to the present invention is described. With regard to Fig. 3 - 11, details of the function of different embodiments of the signal generator are described with regard to a number of signals. Along Fig. 12, finally, the function of an embodiment of the measuring method is shown. Similar entities and reference numbers in different figures have been partially omitted.

[0010] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. However, the following embodiments of the present invention may be variously modified and the range of the present invention is not limited by the following embodiments.

First Embodiment

[0011] In Fig. 1, a measuring system 1, comprising a measuring device 2, comprising a MIMO signal generator 3 is shown. The MIMO signal generator 3 is adapted to transmit a MIMO signal 25 to a device under test 4. The MIMO signal generator 3 comprises a signal generator 10 connected to a signal divider 11, which is connected to a number of signal paths 12_1, 12_2, 12_3, 12_4, 12_5, 12_6, also referred to as plurality of signal paths 12. Each signal path comprises a first filter 13_1, 13_2, 13_3, 13_4, 13_5, 13_6, generally referred to as first filter 13. The filter paths 12 moreover each comprise a mixer 14_1, 14_2, 14_3, 14_4, 14_5, 14_6, generally referred to as mixer 14. Moreover, each filter path 12 comprises a second filter 15_1, 15_2,15_3, 15_4, 15_5, 15_6, generally referred to as filter 15, and an antenna 16_1, 16_2, 16_3, 16_4, 16_5, 16_6, generally referred to as antenna 16.

[0012] The signal generator 10 generates a signal generator output signal 20, which is for example depicted in Fig. 4. The signal generator output signal 20 comprises a plurality of frequency shifted partial MIMO signals. These are arranged on the frequency axis in a non-overlapping manner. Each of the frequency shifted partial MIMO signals has an identical bandwidth, but does not need to comprise the same data content. This does not exclude the frequency shifted partial MIMO signals comprising the same data content, though.

[0013] The frequency shifted partial MIMO signals are spaced apart so that they do not overlap, by spacing the center frequencies of the frequency shifted partial MIMO signals apart by at least the bandwidth a single frequency shifted partial MIMO signal. In order to make the spacing even more secure, an additional spacing of 10% or 20% can be used.

[0014] The signal generator output signal 20 is handed to a signal divider 11, which divides the signal generator output signal 20 onto a plurality of signal paths 12. Each signal path 12 receives the identical signal 21, which is in essence identical to the signal generator output signal 20. Within each of the filter paths 12, first, a filtering by a first filter 13 is performed. This filtering removes signal components outside of the bandwidth of the respective frequency shifted partial MIMO signal. As a next step, a mixing by the respective mixer 14 of the signal path 12 is performed. The filtered frequency shifted partial MIMO signal 22 of the respective signal path 12 is mixed with a local oscillator frequency, which is specific to the respective mixer. The local oscillator signal of the respective mixer is chosen so that the filtered frequency shifted partial MIMO signal 22 of each filter path 12 is mixed to an identical carrier frequency of the resulting MIMO signal 25. This is achieved by frequency shifting the local oscillator signal of each mixer, accordingly.

[0015] Resulting mixed partial MIMO signals 23 of the respective signal paths 12 are handed to second filters 15, which perform an additional filtering. In this filtering, signal components outside of the bandwidth of the MIMO signal 25 are removed. Here, each filter operates on the exact same frequency.

[0016] Finally, resulting filtered partial MIMO signals 24 are transmitted by the antennas 16 to the device under test 4. The signals during transmission are referred to as MIMO signal 25.

[0017] It is important to note that the first filters 13, the second filters 15 and the antennas 16 are optional components. Instead of using antennas 16, the partial MIMO signals 24 can also be provided to a device under test for example by cables.

[0018] Also it is important to note that the MIMO signal generator 3 is not to be understood as restricted to the application in a measuring device 2 or a measuring system 1, as depicted here. Also, a mobile device or a basestation might generate a MIMO signal by use of a MIMO signal generator 3, as depicted here.

Second Embodiment

[0019] In Fig. 2, an embodiment , according to the present invention, of the MIMO signal generator 3 is shown. Here, the MIMO signal generator 3 comprises a first signal generator 10_1 connected to a first signal divider 11_1, and a second signal generator 10_2 connected to a second signal divider 11_2. The first signal generator 10_1 and the first signal divider 11_1 are identical to the signal generator 10 and the signal divider 11 of Fig. 1. Also the further signal processing is identical, as shown there. The individual components of the signal paths 12 have not been displayed for reasons of clarity, here. In fact, the set-up though is identical to the set-up of Fig. 1.

[0020] Here, the second signal generator 10_2 also generates a signal generator output signal 20_2, which is handed to the second signal divider 11_2 and divided onto the different signal paths 12_7, 12_8, 12_9, 12_{10}, 12_{11} and 12_{12}. It is thereby possible to generate a larger number of individual partial MIMO signals 24, which may then be transmitted by use of the antennas 16_1 - 16_{12}.

[0021] This is especially relevant, when the bandwidth of the signal generator 10 of Fig. 1 does not suffice to place all necessary partial MIMO signals side by side in the frequency domain within the signal generator output signal 20, due to the large bandwidth and number of partial MIMO signals. Also this approach is not limited to a second signal generator and signal divider. Also a larger number of individual signal generators and dividers can be used.

[0022] In Fig. 3, a first exemplary partial MIMO signal is shown. It can clearly be seen here that the partial MIMO signal has a carrier frequency and a bandwidth.

[0023] In Fig. 4, a signal generator output signal 20, as shown in Fig. 1 is depicted. Here, one of the partial MIMO signals is not frequency shifted, but remains in the correct frequency location. The remaining partial MIMO signals are frequency shifted with a gap of ten percent of the bandwidth of a partial MIMO signal. Therefore, all six partial MIMO signals are present in the signal generator output signal 20, but are frequency shifted.

[0024] Fig. 5 - Fig. 10 show the individual frequency shifted partial MIMO signals individually. Especially, here the signals 22_1, 22_2, 22_3, 22_4, 22_5 and 22_6 of Fig. 1 are shown. The individual signals 22 no longer comprise the frequency shifted partial MIMO signals of the other measuring paths 12, since they have been filtered by the first filters 13.

[0025] Finally, in Fig. 11, a resulting partial MIMO signal 24 as indicated in Fig. 1 is shown. It has the correct carrier frequency and bandwidth. All different partial MIMO signals 24_1 - 24_6 seem identical in the frequency domain but might contain different data content.

Third Embodiment

[0026] Finally, in Fig. 12 an embodiment of the measuring method is shown. In a first step 100 a plurality of

frequency shifted partial MIMO signals is generated within a first signal generator output signal. These signals are frequency shifted, so that they do not overlap. Advantageously, a gap of ten or twenty percent of the bandwidth of a single partial MIMO signal might be employed between the frequency shifted partial MIMO signals in order to ensure that no overlap can occur.

[0027] In a second step 101 the first signal generator output signal is divided onto a plurality of signal paths.

[0028] In a third step 102 the frequency of each of the plurality of frequency shifted partial MIMO signals is shifted to a joint carrier frequency of the final MIMO signal. This results in a plurality of partial MIMO signals, forming the final MIMO signal.

[0029] It is important to note, that the method embodiment and the device embodiments very closely relate to each other and that features described along Fig. 1 - Fig. 11 can also be employed the method shown in Fig. 12.

[0030] The embodiments of the present invention can be implemented by hardware, software, or any combination thereof. Various embodiments of the present invention may be implemented by one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, microcontrollers, microprocessors, or the like.

[0031] Various embodiments of the present invention may also be implemented in the form of software modules, processes, functions, or the like which perform the features or operations described above. Software code can be stored in a memory unit so that it can be executed by a processor. The memory unit may be located inside or outside the processor and can communicate date with the processor through a variety of known means.

[0032] The invention is not limited to the examples and especially not to a MIMO signal generator within a measuring device. The MIMO signal generator can also be employed in a base station or a mobile station or any other device generating memo signals. The characteristics of the exemplary embodiments can be used in any advantageous combination.

Claims

1. A MIMO signal generator (3), adapted to generate a MIMO signal (25), comprising:

- a first signal generator (10_1),
- a second signal generator (10_2) different from the first signal generator (10_1),
- a first signal divider (11_1),
- a second signal divider (11_2) different from the first signal divider (11_1),

and a frequency shifter (14),

- wherein the first signal generator (10_1) is adapted to generate a plurality of frequency shifted partial MIMO signals within an output signal of the first signal generator (10_1), the plurality of frequency shifted partial MIMO signals being arranged on a frequency axis in a non-overlapping manner by placing a carrier frequency of all but one of the plurality of frequency shifted partial MIMO signals to different frequencies, wherein the plurality of frequency shifted partial MIMO signals comprises N frequency shifted partial MIMO signals,

wherein the first signal divider (11_1) is adapted to divide the output signal of the first signal generator (10_1) onto a plurality of N signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6),

- wherein the second signal generator (10_2) is adapted to generate a plurality of frequency shifted partial MIMO signals within an output signal of the second signal generator (10_2), the plurality of frequency shifted partial MIMO signals being arranged on a frequency axis in a non-overlapping manner by placing a carrier frequency of all but one of the plurality of frequency shifted partial MIMO signals to different frequencies, wherein the plurality of frequency shifted partial MIMO signals comprises M frequency shifted partial MIMO signals, wherein the second signal divider (11_2) is adapted to divide the output signal of the second signal generator (10_2) onto a plurality of M signal paths (12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),

wherein the different frequencies are spaced apart at least by a bandwidth of the MIMO signal (25), or

wherein the different frequencies are spaced apart at least by 110% of a bandwidth of the MIMO signal (25), preferably by 120% of the bandwidth of the MIMO signal (25),

wherein each of the plurality of N and M signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) additionally comprises an antenna (16_1, 16_2, 16_3, 16_4, 16_5, 16_6) for transmitting a partial MIMO signal over the air, wherein the frequency shifter (14) comprises a frequency shifting device (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) in at least each but one of the plurality of signals paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),

wherein each frequency shifting device (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) is adapted to shift the frequency of one of the plurality of frequency shifted partial MIMO signals to a joint carrier frequency, resulting in a plurality of partial MIMO signals, forming the MIMO signal.

2. The MIMO signal generator (3) of claim 1, wherein at least one signal path (12_1, 12_2, 12_3, 12_4, 12_8, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}), preferably each, of the plurality of signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) additionally comprises a first filter (13_1, 13_2, 13_3, 13_4, 13_5, 13_6) arranged between the first and second signal divider (11_1, 11_2) and the frequency shifting device (14), adapted to remove signals outside of a frequency shifted bandwidth of the plurality of signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) .

3. The MIMO signal generator (3) of claim 2, wherein at least one, preferably each of the plurality of signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) additionally comprises a second filter (15_1, 15_2, 15_3, 15_4, 15_5, 15_6) arranged between the frequency shifting device (14) and an output of the respective signal path (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) of the plurality of signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6), adapted to remove signals outside of a bandwidth of the MIMO signal (25).

4. The MIMO signal generator (3) of any of claims 1 to 3, wherein the frequency shifting device (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) is constituted by mixers.

5. The MIMO signal generator (3) of claim 4, wherein the mixers are connected to common reference frequency means.

6. The MIMO signal generator (3) of any of claims 1 to 5, wherein the first and second signal divider (11_1, 11_2) are arranged in a first housing, and wherein the frequency shifter (14) is arranged in a second housing.

7. An apparatus (2) comprising a MIMO signal generator (3) according to any of claims 1 to 6, wherein the apparatus (2) is a mobile station or a base station or measuring device.

8. A measuring system (1), comprising a MIMO signal generator (3) according to any of claims 1 to 6, and a device under test (4),

wherein the device under test (4) comprises a MIMO signal receiver,
wherein the MIMO signal generator (3) is adapted to provide the MIMO signal (25) to the device under test (4), and
wherein the device under test (4) is adapted to receive the MIMO signal (25) using the MIMO signal receiver.

9. The measuring system of claim 8, wherein the MIMO signal receiver is adapted to receive different data streams of a same frequency using separate antennas.

10. The measuring system (1) of claim 8 or 9, wherein the MIMO signal generator (3) is adapted to transmit the MIMO signal (25) to the device under test over the air using the antennas (16) of the plurality of signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6).

11. The measuring system (1) of claim 9,

wherein the measuring system comprises an anechoic measuring chamber, and
wherein the device under test (4) and at least the antennas of the signals paths are arranged within the anechoic measuring chamber.

12. Method for generating a MIMO signal, comprising:

- generating, by a first signal generator (10), a plurality of frequency shifted partial MIMO signals within an output signal of the first signal generator (20), the plurality of frequency shifted partial MIMO signals being arranged on a frequency axis in a non-overlapping manner by placing a carrier frequency of all but one of the plurality of frequency shifted partial MIMO signals to different frequencies, wherein the plurality of frequency shifted partial MIMO signals comprises N frequency shifted partial MIMO signals,
- dividing, by a first signal divider (11_1) the output signal of the first signal generator (20) onto a plurality of N signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6),
- generating, by a second signal generator (10), a plurality of frequency shifted partial MIMO signals within an output signal of the second signal generator (20), the plurality of frequency shifted partial MIMO signals being arranged on a frequency axis in a non-overlapping manner by placing a carrier frequency of all but one of the plurality of frequency shifted partial MIMO signals to different frequencies, wherein the plurality of frequency shifted partial MIMO signals comprises M frequency shifted partial MIMO signals,
- dividing, by a second signal divider (11_2), the output signal of the second signal generator (10_2) onto a plurality of M signal paths (12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) ,

wherein the different frequencies are spaced apart at least by a bandwidth of the MIMO signal (25), or
wherein the different frequencies are spaced apart at least by 110% of a band-

width of the MIMO signal (25), preferably by 120% of the bandwidth of the MIMO signal (25),

wherein each of the plurality of N and M signal paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) additionally comprises an antenna (16_1, 16_2, 16_3, 16_4, 16_5, 16_6) transmitting a partial MIMO signal over the air, wherein the frequency shifter (14) comprises a frequency shifting device (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) in at least each but one of the plurality of signals paths (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),

each frequency shifting device (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) shifting the frequency of one of the plurality of frequency shifted partial MIMO signals to a joint carrier frequency, resulting in a plurality of partial MIMO signals, forming the MIMO signal.

Patentansprüche

1. MIMO-Signalerzeuger (3), der angepasst ist, ein MIMO-Signal (25) zu erzeugen, und Folgendes umfasst:

- einen ersten Signalerzeuger (10_1),
- einen zweiten Signalerzeuger (10_2), der sich vom ersten Signalerzeuger (10_1) unterscheidet,
- einen ersten Signalteiler (11_1),
- einen zweiten Signalteiler (11_2), der sich vom ersten Signalteiler (11_1) unterscheidet, und einen Frequenzverschieber (14),
- wobei der erste Signalerzeuger (10_1) angepasst ist, eine Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen in einem Ausgangssignal des ersten Signalerzeugers (20_1) zu erzeugen, wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen durch Platzieren einer Trägerfrequenz von allen außer einem der Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen auf verschiedene Frequenzen auf einer Frequenzachse in einer nicht überlappenden Weise angeordnet sind, wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen N frequenzverschobene teilweise MIMO-Signale umfasst, wobei der erste Signalteiler (11_1) angepasst ist, das Ausgangssignal des ersten Signalerzeugers (20_1) auf eine Vielzahl von N Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6) zu teilen,
- wobei der zweite Signalerzeuger (10_2) angepasst ist, eine Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen in einem Ausgangssignal des zweiten Signalerzeugers (20_2) zu erzeugen, wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen durch Platzieren einer Trägerfrequenz von allen außer einem der Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen auf verschiedene Frequenzen auf einer Frequenzachse in einer nicht überlappenden Weise angeordnet sind, wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen M frequenzverschobene teilweise MIMO-Signale umfasst, wobei der zweite Signalteiler (11_2) angepasst ist, das Ausgangssignal des zweiten Signalerzeugers (20_2) auf eine Vielzahl von M Signalpfaden (12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) zu teilen,

wobei die verschiedenen Frequenzen mindestens um eine Bandbreite des MIMO-Signals (25) beabstandet sind, oder
wobei die verschiedenen Frequenzen mindestens um 110% einer Bandbreite des MIMO-Signals (25), vorzugsweise um 120% der Bandbreite des MIMO-Signals (25), beabstandet sind,
wobei jeder der Vielzahl von N und M Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) zusätzlich eine Antenne (16_1, 16_2, 16_3, 16_4, 16_5, 16_6) zum Übertragen eines teilweisen MIMO-Signals über die Luft umfasst,
wobei der Frequenzverschieber (14) eine Frequenzverschiebungsvorrichtung (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) in mindestens jedem außer einem der Vielzahl von Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) umfasst,
wobei jede Frequenzverschiebungsvorrichtung (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) angepasst ist, die Frequenz von einem der Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen zu einer gemeinsamen Trägerfrequenz zu verschieben, was in einer Vielzahl von teilweisen MIMO-Signalen resultiert, die das MIMO-Signal bilden.

2. MIMO-Signalerzeuger (3) nach Anspruch 1, wobei mindestens ein Signalpfad (12_1, 12_2, 12_3, 12_4, 12_8, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}), vorzugsweise jeder der Vielzahl von Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) zusätzlich ein erstes Filter (13_1, 13_2, 13_3, 13_4, 13_5, 13_6) umfasst, das zwischen dem ersten und dem zweiten Signalteiler (11_1, 11_2) und der Frequenzverschiebungsvorrichtung (14) angeordnet und angepasst ist, Signale außerhalb einer frequenzverschobenen Bandbreite der Vielzahl von Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) zu entfernen.

3. MIMO-Signalerzeuger (3) nach Anspruch 2, wobei mindestens einer, vorzugsweise jeder der Vielzahl von Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) zusätzlich ein zweites Filter (15_1, 15_2, 15_3, 15_4, 15_5, 15_6) umfasst, das zwischen der Frequenzverschiebungsvorrichtung (14) und einem Ausgang des jeweiligen Signalpfads (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) der Vielzahl von Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6) angeordnet und angepasst ist, Signale außerhalb einer Bandbreite des MIMO-Signals (25) zu entfernen.

4. MIMO-Signalerzeuger (3) nach einem der Ansprüche 1 bis 3, wobei die Frequenzverschiebungsvorrichtung (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) durch Mischer konstituiert ist.

5. MIMO-Signalerzeuger (3) nach Anspruch 4, wobei die Mischer mit gemeinsamen Referenzfrequenzmitteln verbunden sind.

6. MIMO-Signalerzeuger (3) nach einem der Ansprüche 1 bis 5,

wobei der erste und der zweite Signalteiler (11_1, 11_2) in einem ersten Gehäuse angeordnet sind, und
wobei der Frequenzverschieber (14) in einem zweiten Gehäuse angeordnet ist.

7. Einrichtung (2), die einen MIMO-Signalerzeuger (3) nach einem der Ansprüche 1 bis 6 umfasst, wobei die Einrichtung (2) eine Mobilstation oder eine Basisstation oder eine Messvorrichtung ist.

8. Messsystem (1), das einen MIMO-Signalerzeuger (3) nach einem der Ansprüche 1 bis 6 und eine zu testende Vorrichtung (4) umfasst,

wobei die zu testende Vorrichtung (4) einen MIMO-Signalempfänger umfasst,
wobei der MIMO-Signalerzeuger (3) angepasst ist, das MIMO-Signal (25) der zu testenden Vorrichtung (4) bereitzustellen, und
wobei die zu testende Vorrichtung (4) angepasst ist, das MIMO-Signal (25) unter Verwendung des MIMO-Signalempfängers zu empfangen.

9. Messsystem nach Anspruch 8, wobei der MIMO-Signalempfänger angepasst ist, unter Verwendung von separaten Antennen verschiedene Datenströme einer selben Frequenz zu empfangen.

10. Messsystem (1) nach Anspruch 8 oder 9, wobei der MIMO-Signalerzeuger (3) angepasst ist, das MIMO-Signal (25) unter Verwendung der Antennen (16) der Vielzahl von Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6) über die Luft zur zu testenden Vorrichtung zu übertragen.

11. Messsystem (1) nach Anspruch 9,

wobei das Messsystem eine nicht echogene Messkammer umfasst, und
wobei die zu testende Vorrichtung (4) und mindestens die Antennen der Signalpfade in der nicht echogenen Messkammer angeordnet sind.

12. Verfahren zum Erzeugen eines MIMO-Signals, das Folgendes umfasst:

- Erzeugen einer Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen durch einen ersten Signalerzeuger (10_1) in einem Ausgangssignal des ersten Signalerzeugers (20_1), wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen durch Platzieren einer Trägerfrequenz von allen außer einem der Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen auf verschiedene Frequenzen auf einer Frequenzachse in einer nicht überlappenden Weise angeordnet sind, wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen N frequenzverschobene teilweise MIMO-Signale umfasst,
- Teilen des Ausgangssignals des ersten Signalerzeugers (20_1) durch einen ersten Signalteiler (11_1) auf eine Vielzahl von N Signalpfade (12_1, 12_2, 12_3, 12_4, 12_5, 12_6),
- Erzeugen einer Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen durch einen zweiten Signalerzeuger (10_2) in einem Ausgangssignal des zweiten Signalerzeugers (202), wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen durch Platzieren einer Trägerfrequenz von allen außer einem der Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen auf verschiedene Frequenzen auf einer Frequenzachse in einer nicht überlappenden Weise angeordnet sind, wobei die Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen M frequenzverschobene teilweise MIMO-Signale umfasst,
- Teilen des Ausgangssignals des zweiten Signalerzeugers (20_2) durch einen zweiten Signalteiler (11_2) auf eine Vielzahl von M Signalpfade (12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),

wobei die verschiedenen Frequenzen mindestens um eine Bandbreite des MIMO-Signals (25) beabstandet sind, oder
wobei die verschiedenen Frequenzen mindestens um 110% einer Bandbreite des MI-

MO-Signals (25), vorzugsweise um 120% der Bandbreite des MIMO-Signals (25), beabstandet sind,
wobei jeder der Vielzahl von N und M Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) zusätzlich eine Antenne (16_1, 16_2, 16_3, 16_4, 16_5, 16_6) umfasst, die ein teilweises MIMO-Signal über die Luft überträgt,
wobei der Frequenzverschieber (14) eine Frequenzverschiebungsvorrichtung (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) in mindestens jedem außer einem der Vielzahl von Signalpfaden (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) umfasst, wobei jede Frequenzverschiebungsvorrichtung (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) angepasst ist, die Frequenz von einem der Vielzahl von frequenzverschobenen teilweisen MIMO-Signalen zu einer gemeinsamen Trägerfrequenz zu verschieben, was in einer Vielzahl von teilweisen MIMO-Signalen resultiert, die das MIMO-Signal bilden.

Revendications

1. Générateur de signal à entrées multiples et sorties multiples, MIMO (3), conçu pour générer un signal MIMO (25), comprenant :

- un premier générateur de signal (10_1),
- un second générateur de signal (10_2) différent du premier générateur de signal (10_1),
- un premier diviseur de signal (11_1),
- un second diviseur de signal (11_2) différent du premier diviseur de signal (11_1),

et un décaleur de fréquence (14),

- dans lequel le premier générateur de signal (10_1) est conçu pour générer une pluralité de signaux MIMO partiels décalés en fréquence au sein d'un signal de sortie du premier générateur de signal (20_1), la pluralité de signaux MIMO partiels décalés en fréquence étant agencés sur un axe fréquentiel d'une manière non superposée par le placement d'une fréquence porteuse de tous sauf l'un de la pluralité de signaux MIMO partiels décalés en fréquence à différentes fréquences, dans lequel la pluralité de signaux MIMO partiels décalés en fréquence comprend N signaux MIMO partiels décalés en fréquence, dans lequel le premier diviseur de signal (11_1) est conçu pour diviser le signal de sortie du premier générateur de signal (20_1) sur une pluralité de N trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6),
- dans lequel le second générateur de signal (10_2) est conçu pour générer une pluralité de signaux MIMO partiels décalés en fréquence au sein d'un signal de sortie du second générateur de signal (20_2), la pluralité de signaux MIMO partiels décalés en fréquence étant agencés sur un axe fréquentiel d'une manière non superposée par le placement d'une fréquence porteuse de tous sauf l'un de la pluralité de signaux MIMO partiels décalés en fréquence à différentes fréquences, dans lequel la pluralité de signaux MIMO partiels décalés en fréquence comprend M signaux MIMO partiels décalés en fréquence, dans lequel le second diviseur de signal (11_2) est conçu pour diviser le signal de sortie du second générateur de signal (20_2) sur une pluralité de M trajets de signal (12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),

dans lequel les différentes fréquences sont espacées au moins par une bande passante du signal MIMO (25), ou
dans lequel les différentes fréquences sont espacées au moins par 110 % d'une bande passante du signal MIMO (25), de préférence par 120 % de la bande passante du signal MIMO (25),
dans lequel chacun de la pluralité de *N* et *M* trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) comprend en outre une antenne (16_1, 16_2, 16_3, 16_4, 16_5, 16_6) pour l'émission d'un signal MIMO partiel par voie hertzienne,
dans lequel le décaleur de fréquence (14) comprend un dispositif de décalage en fréquence (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) dans au moins chacun sauf l'un de la pluralité de trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),
dans lequel chaque dispositif de décalage en fréquence (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) est conçu pour décaler la fréquence de l'un de la pluralité de signaux MIMO partiels décalés en fréquence vers une fréquence porteuse conjointe, résultant en une pluralité de signaux MIMO partiels, formant le signal MIMO.

2. Générateur de signal MIMO (3) selon la revendication **1,**
dans lequel au moins un trajet de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}), de préférence chacun de la pluralité de trajets de signal (12_1, 12_2, 12_3, 12_4, 12_8, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) comprend en outre un premier filtre (13_1, 13_2, 13_3, 13_4, 13_5, 13_6) agencé entre le premier et le second diviseur de signal (11_1, 11_2) et le dispositif de décalage en fréquence (14), conçu pour éliminer des signaux en dehors d'une bande passante décalée en fréquence de la pluralité de trajets

de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) .

3. Générateur de signal MIMO (3) selon la revendication 2,
dans lequel au moins l'un, de préférence chacun de la pluralité de trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) comprend en outre un second filtre (15_1, 15_2, 15_3, 15_4, 15_5, 15_6) agencé entre le dispositif de décalage en fréquence (14) et une sortie du trajet de signal respectif (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) de la pluralité de trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6), conçu pour éliminer des signaux en dehors d'une bande passante du signal MIMO (25).

4. Générateur de signal MIMO (3) selon l'une quelconque des revendications 1 à 3, dans lequel le dispositif de décalage en fréquence (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) est constitué par des mélangeurs.

5. Générateur de signal MIMO (3) selon la revendication 4,
dans lequel les mélangeurs sont connectés à des moyens de fréquence de référence commune.

6. Générateur de signal MIMO (3) selon l'une quelconque des revendications 1 à 5,

dans lequel le premier et le second diviseur de signal (11_1, 11_2) sont agencés dans un premier boîtier, et
dans lequel le décaleur de fréquence (14) est agencé dans un second boîtier.

7. Appareil (2) comprenant un générateur de signal MIMO (3) selon l'une quelconque des revendications 1 à 6,
dans lequel l'appareil (2) est une station mobile ou une station de base ou un dispositif de mesure.

8. Système de mesure (1), comprenant un générateur de signal MIMO (3) selon l'une quelconque des revendications 1 à 6, et un dispositif en cours de test (4),

dans lequel le dispositif en cours de test (4) comprend un récepteur de signal MIMO,
dans lequel le générateur de signal MIMO (3) est conçu pour fournir le signal MIMO (25) au dispositif en cours de test (4), et
dans lequel le dispositif en cours de test (4) est conçu pour recevoir le signal MIMO (25) à l'aide du récepteur de signal MIMO.

9. Système de mesure selon la revendication 8,
dans lequel le récepteur de signal MIMO est conçu pour recevoir différents flux de données d'une même fréquence à l'aide d'antennes séparées.

10. Système de mesure (1) selon la revendication 8 ou 9, dans lequel le générateur de signal MIMO (3) est conçu pour émettre le signal MIMO (25) vers le dispositif en cours de test par voie hertzienne à l'aide des antennes (16) de la pluralité de trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6).

11. Système de mesure (1) selon la revendication 9,

dans lequel le système de mesure comprend une chambre de mesure anéchoïque, et
dans lequel le dispositif en cours de test (4) et au moins les antennes des trajets de signal sont agencés à l'intérieur de la chambre de mesure anéchoïque.

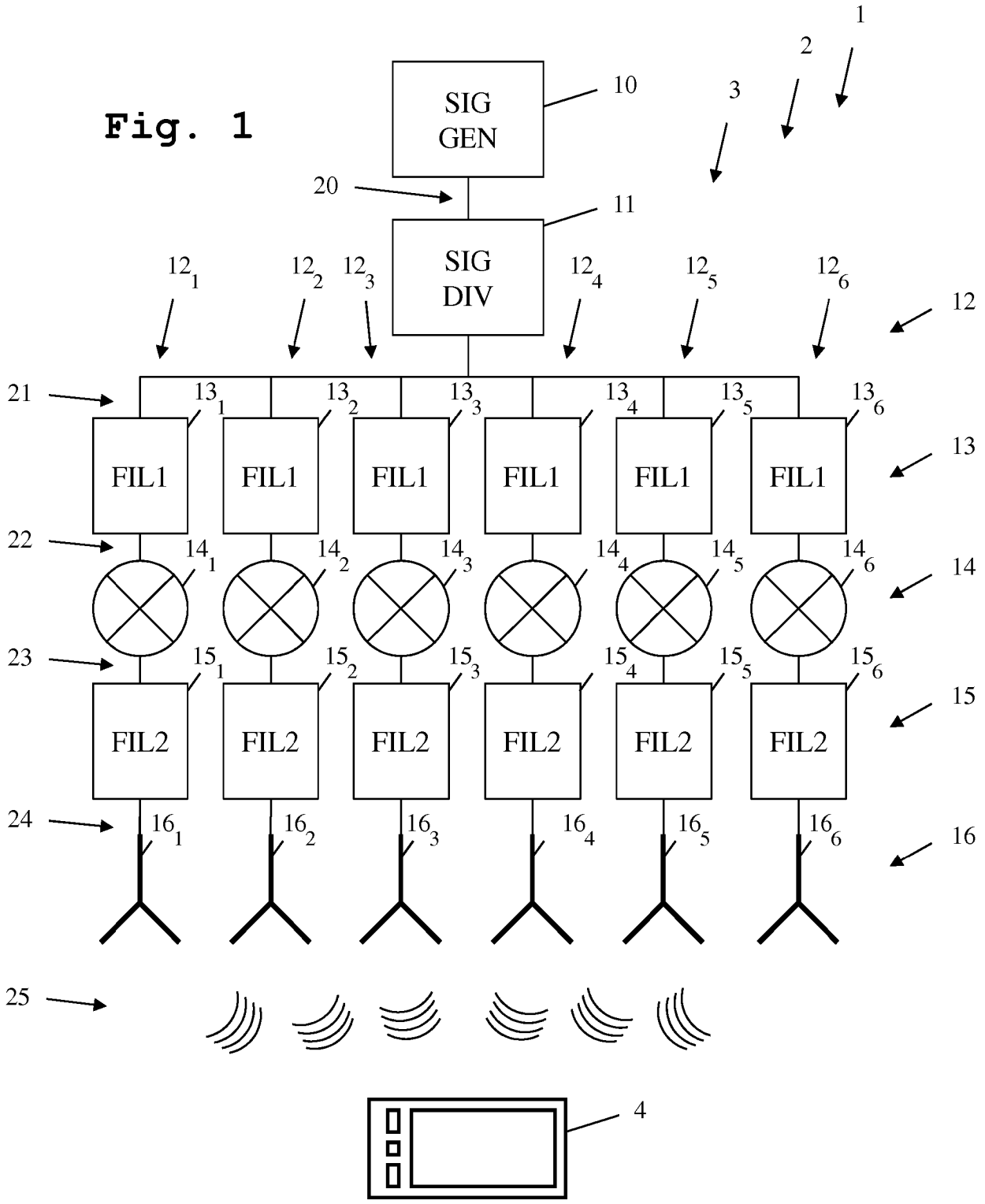
12. Procédé pour la génération d'un signal MIMO, comprenant :

- la génération, par un premier générateur de signal (10_1), d'une pluralité de signaux MIMO partiels décalés en fréquence au sein d'un signal de sortie du premier générateur de signal (20_1), la pluralité de signaux MIMO partiels décalés en fréquence étant agencés sur un axe fréquentiel d'une manière non superposée par le placement d'une fréquence porteuse de tous sauf l'un de la pluralité de signaux MIMO partiels décalés en fréquence à différentes fréquences, dans lequel la pluralité de signaux MIMO partiels décalés en fréquence comprend N signaux MIMO partiels décalés en fréquence,
- la division, par un premier diviseur de signal (11_1), du signal de sortie du premier générateur de signal (20_1) sur une pluralité de N trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6),
- la génération, par un second générateur de signal (10_2), d'une pluralité de signaux MIMO partiels décalés en fréquence au sein d'un signal de sortie du second générateur de signal (20_2), la pluralité de signaux MIMO partiels décalés en fréquence étant agencés sur un axe fréquentiel d'une manière non superposée par le placement d'une fréquence porteuse de tous sauf l'un de la pluralité de signaux MIMO partiels décalés en fréquence à différentes fréquences, dans lequel la pluralité de signaux MIMO partiels décalés en fréquence comprend M signaux MIMO partiels décalés en fréquence,
- la division, par un second diviseur de signal (11_2), du signal de sortie du second générateur de signal (20_2) sur une pluralité de M trajets de signal (12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),

dans lequel les différentes fréquences sont

espacées au moins par une bande passante du signal MIMO (25), ou
dans lequel les différentes fréquences sont espacées au moins par 110 % d'une bande passante du signal MIMO (25), de préférence par 120 % de la bande passante du signal MIMO (25),
dans lequel chacun de la pluralité de *N* et *M* trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}) comprend en outre une antenne (16_1, 16_2, 16_3, 16_4, 16_5, 16_6) émettant un signal MIMO partiel par voie hertzienne,
dans lequel le décaleur de fréquence (14) comprend un dispositif de décalage en fréquence (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) dans au moins chacun sauf l'un de la pluralité de trajets de signal (12_1, 12_2, 12_3, 12_4, 12_5, 12_6, 12_7, 12_8, 12_9, 12_{10}, 12_{11}, 12_{12}),
chaque dispositif de décalage en fréquence (14_1, 14_2, 14_3, 14_4, 14_5, 14_6) décalant la fréquence de l'un de la pluralité de signaux MIMO partiels décalés en fréquence vers une fréquence porteuse conjointe, résultant en une pluralité de signaux MIMO partiels, formant le signal MIMO.

Fig. 1


1
2
3
SIG GEN
10
20
11
SIG DIV
12_1
12_2
12_3
12_4
12_5
12_6
12
21
13_1
13_2
13_3
13_4
13_5
13_6
FIL1
13
22
14_1
14_2
14_3
14_4
14_5
14_6
14
23
15_1
15_2
15_3
15_4
15_5
15_6
FIL2
15
24
16_1
16_2
16_3
16_4
16_5
16_6
16
25
4

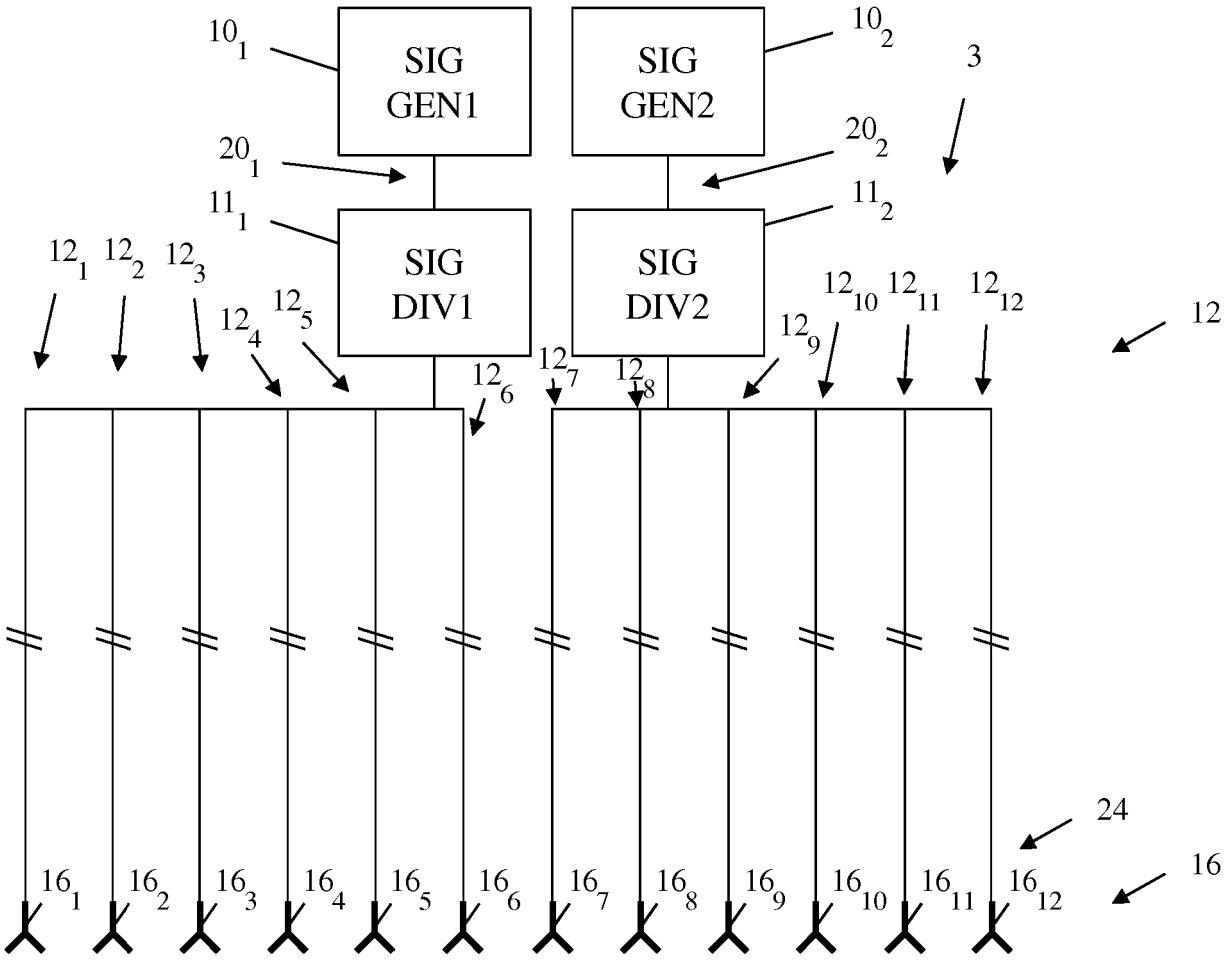

SIG GEN1
SIG GEN2
SIG DIV1
SIG DIV2
10_1
10_2
3
20_1
20_2
11_1
11_2
12_1 12_2 12_3 12_4 12_5 12_6 12_7 12_8 12_9 12_{10} 12_{11} 12_{12}
12
24
16
16_1 16_2 16_3 16_4 16_5 16_6 16_7 16_8 16_9 16_{10} 16_{11} 16_{12}

Fig. 2

Fig. 3

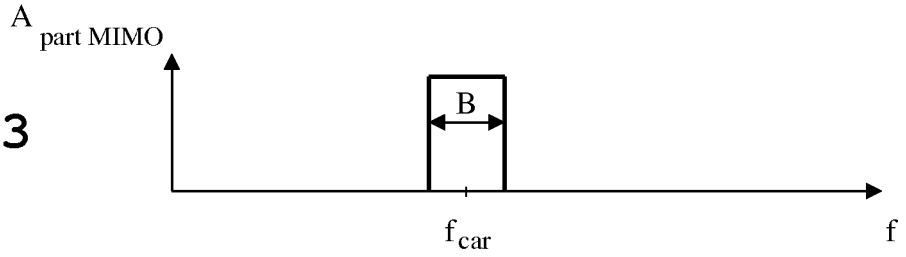


Fig. 4

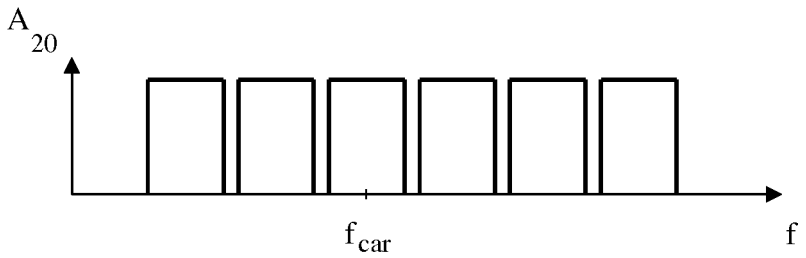


Fig. 11

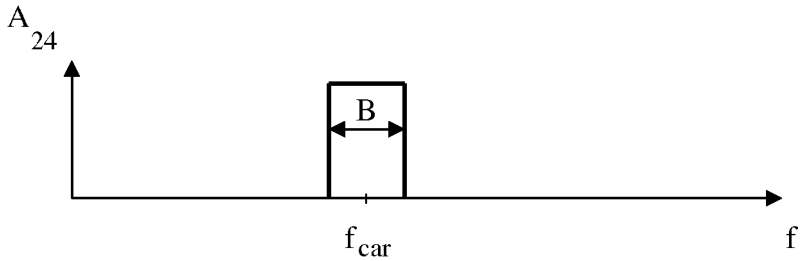


Fig. 5

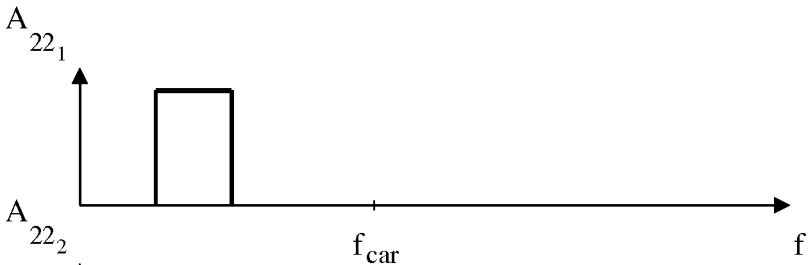


Fig. 6

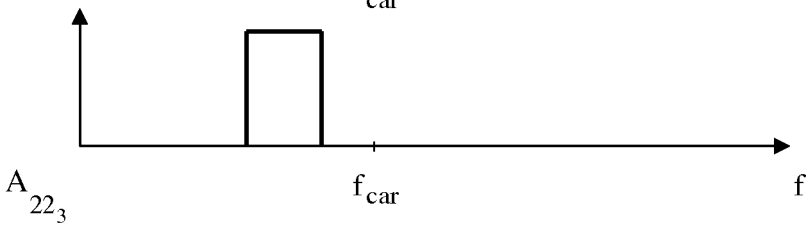


Fig. 7

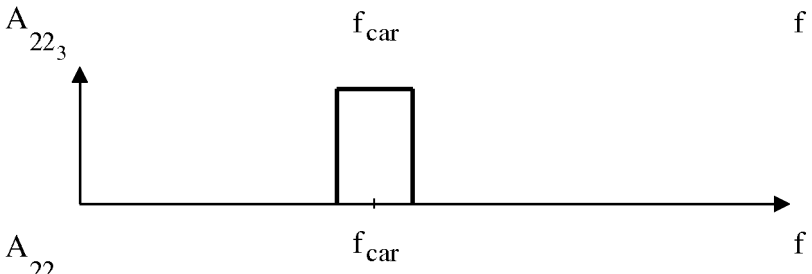


Fig. 8

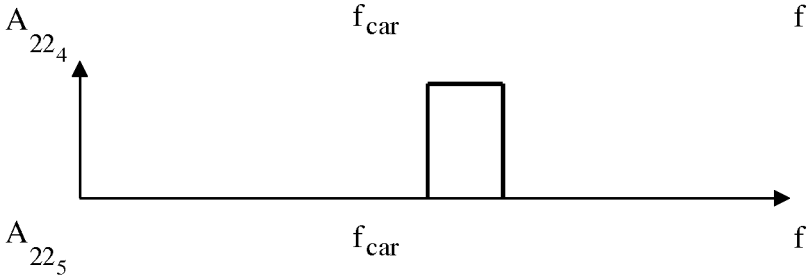


Fig. 9

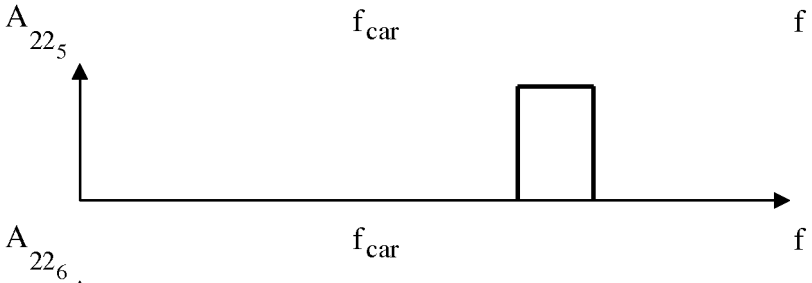
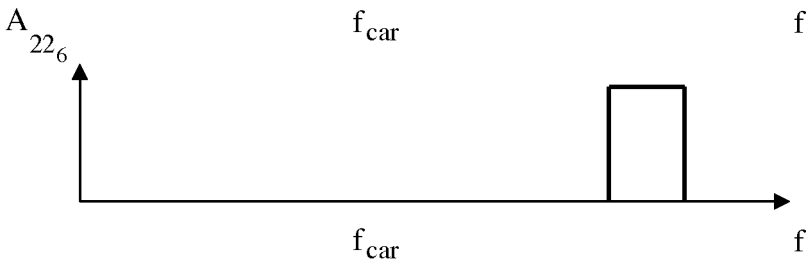


Fig. 10



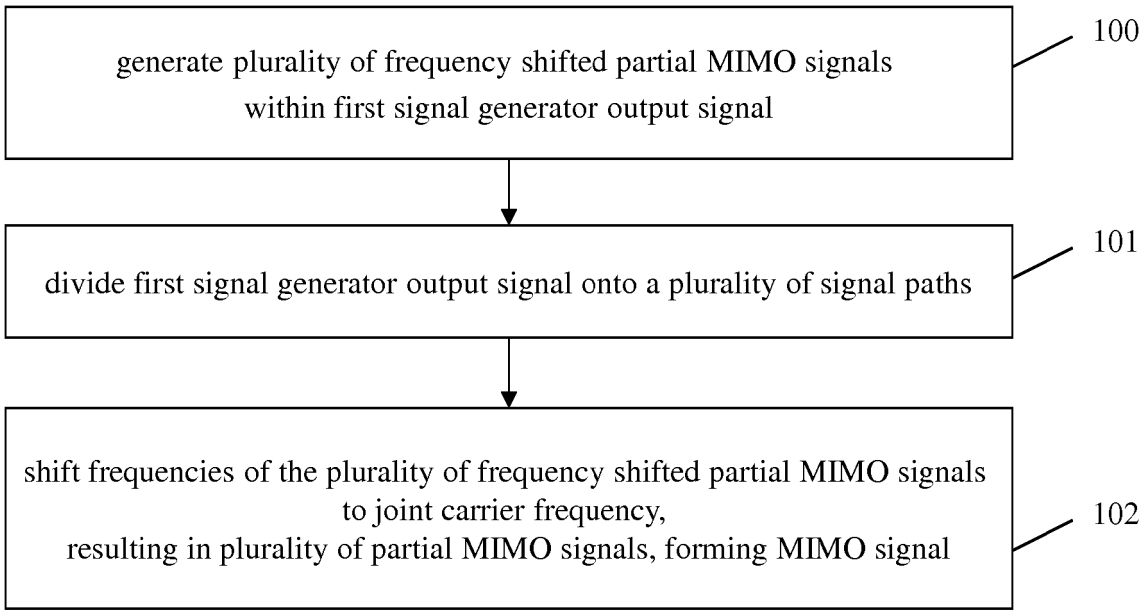

generate plurality of frequency shifted partial MIMO signals within first signal generator output signal
100
divide first signal generator output signal onto a plurality of signal paths
101
shift frequencies of the plurality of frequency shifted partial MIMO signals to joint carrier frequency, resulting in plurality of partial MIMO signals, forming MIMO signal
102

Fig. 12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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